Observations on the Biology of the Giant Palm-Boring Beetle, *Dinapate wrighti* Horn (Coleoptera: Bostrichidae)

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Abstract: Laboratory and field studies were made on the biology of *Dinapate wrighti* Horn, from the Colorado Desert of southern California. Grubs were studied and collected in both well-known and remote palm oases of the California fan palm, *Washingtonia filifera*, in the area of Palm Springs, California, and in Borrego Desert State Park, California. Five hundred fifty-seven specimens were reared and studied under artificial conditions.

Since its discovery by W. G. Wright (1886), and the erecting of a new genus in which to place the species by Horn, the giant (33 to 51 mm.) palm-boring beetle, *Dinapate wrighti* Horn, has been collected but little intensive study has been devoted to this highly specialized desert insect. Horn, in the original paper describes both adults and larva in detail. Since then, several papers have appeared, primarily in rare technical works. Comstock (1922) summarizes the early papers and describes the grub and pupa. Most of the work consisted of collecting palm trunk sections, rearing from the grubs, and observing under artificial conditions. Other than this it has been difficult to do more than hypothesize on the biology and life history of the beetle, since it is nocturnal and lives most of its life within the palms, both as a grub and an adult.

In September, 1960, I made a field trip to the southwest desert (Colorado Desert) of California with Mr. W. G. Abbott to Thousand Palms, a privately owned grove of several hundred fan palms, *Washingtonia filifera*. The owner called our attention to some fallen palms which had lain for several years. Some were riddled with the large exit holes of *Dinapate*. We cut a section of palm trunk about five feet long and twelve inches in diameter and came upon several grubs. The section was transported to the museum insectary. During the months of July and August, 1962, eight beetles—three males and five females—emerged. All were placed in a ten-gallon terrarium with some fresh palm cuttings, where they remained for the most part beneath the cuttings away from light. I was hopeful that they might copulate; but the males showed no

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interest in the females and upon contact they fought with the females as well as with other males. No feeding took place and within ten days all died.

On a subsequent trip to the same grove, the owner told us that occasionally the beetles were found clinging to his front porch screen, apparently attracted to the light. Martin (1917) states that all beetles he observed shunned light. In ten years of working with this species in the insectary, I found them repelled by light in every instance. Since they are apparently blind, it is my conclusion that in their swift and bumbling flight, they must have struck the wire screen and been injured. All attempts at collecting them by black light during their hatching season (June through September) were unsuccessful. Lloyd Tevis, director of the U.C. research station at Deep Canyon, Palm Desert, California (pers. comm.), reports that entomologists working at the research station had the same experience. Opposing my supposition is information that two entomologists from the agriculture department in Riverside, California, have collected the adults with black light, at least on two occasions. Their statement, which I heard "second-hand," was that when there was no moon or wind, the beetles came to light. I have been unable to verify this; but I have used black light under similar climatic conditions without success.

For years it was believed, with good reason, that *Dinapate* was host-specific on the fan palm, *W. filifera*. My investigations support this, and I believe now that they oviposit only in this species of palm. Davis (1940) and Fisher (1950) mention that the beetle has attacked date palms in the Coachella Valley. Elmer, of the University of California citrus research center and agricultural experiment station at Riverside, California, reports that the beetles have attacked California fan palms in the foothills of the Coachella Valley and occasionally have been found in an isolated date palm in that area, but not in date palms on the valley floor. Stickney, Barnes and Simmons also report that *D. wrighti* has damaged date palms in the Palm Springs area, but not those in the commercial date gardens in the valley. Stickney (1928–29) reports that the damage he observed was caused mainly by the feeding of adults. Davis (1928) commenting on the damage to transplanted palms (*W. filifera*) in Palm Springs, California, states that about 90 per cent of these trees were injured by the beetles burrowing down into the crowns and also that most of the large palms transplanted thirty to forty years ago showed the effects of beetle damage. An accumulation of excelsior-like frass near the growing tips of the trees is evidence of the presence of *D. wrighti*. Elmer (pers. comm.) reported finding the beetle in *Washingtonia robusta* at the Dunlap Nursery, Thermal, California. I investigated this nursery on the invitation of Mr. Phillip E. Mee, representative, and through his cooperation and the help of some of his gardeners examined damage to eight *W. robusta* which had been marked by Dr. Elmer. This damage, I concluded, was from feeding, since it was different from the attacks

on the *W. filifera*. The damage I saw in the *robusta* was for the most part confined to long, deep furrows in the leaf stems and near the crown. A check with the Dunlap Nursery two years later revealed that no more damage had been found in the *W. robusta*. I concluded that this damage was done by beetles from a flight searching for *W. filifera*.

According to Palm Springs residents, the "main flight of the beetles occurs about July 1–15, although some beetles were active as early as June 15th and as late as August." These "flights" in all probability are movements of males from a brood searching for a new stand of palms where mating can take place with females from a different brood, or an exodus of a brood of both males and females caused by heavy competition.

In *W. filifera*, I have never seen "furrowing" damage, although it may occur from feeding. The females make definite entrances and tunnel to the bases of the crown, where, on the two trees sectioned, I have found as many as seven females in what might be termed a "communal" chamber. Upon reaching this area, especially in young palms, the base of the crown is completely eaten away and the leaves may easily be lifted out. This chamber is partly filled with a soft, thick, moist material which is composed of sap, chewed fibers and fecal matter. The beetles (females) were partly submerged, and I thought they were dead. When prodded however, they moved.

Although I did not find eggs or young grubs in a microscopic examination of samples of this bottom material, I feel that this must be where oviposition takes place. I base this upon the small size of the eggs (1.75 mm. by .90 mm. average) and the almost microscopic size of the newly hatched grubs. My failure to find newly hatched grubs may have been because they had moved down into the network of fine fibers at the bottom of the "chamber." Hubbard (1897) writes, in reference to the newly hatched grubs, that he found some of their borings under the fibers of the leaf bases, where they were not "larger than a friction match." I believe these borings must have been made by something other than *Dinapate* grubs. Because of their extremely small size, it seems unlikely that they can make an entrance to any part of the tough fibrous palms. If so, the entrance would be smaller than a friction match. I believe that the newly hatched grubs first feed on the soft, moist material in the "communal" chamber. By the time their mandibles are capable of attacking the softest fibers (at the base of the crown), they are probably at the bottom of the chamber, where they can begin boring down the bole of the palm.

The borings of the females occur at the axes of the leaf stems, and those of the grubs within the tree bole, where they may "powder" the portion directly below the crown. The grubs usually pack their tunnels behind them with frass.

In older palms thirty to fifty feet high that have recently been attacked by *D. wrighti*, exit holes of the adults were found to be concentrated in areas some

eight to twelve feet below the crown. In older palms that have nurtured many broods, exit holes sometimes appear from the top portion to near the base of the bole. The palm shown in the photograph was literally pulverized with exit holes from top to bottom (Fig. 1). Probably the only reason it remained upright was that the hard-packed tunnels of the grubs strengthened it; the frass is so tightly packed that as it dries and hardens it becomes part of the palm, fusing with the fibers like plastic wood. Pupal chambers of adults are constructed within an inch or so from the outer surface and therefore have little effect in weakening the palm. It is only within a few feet below the crown that the borings of the developing grubs pulverize the palm seriously enough to cause eventual collapse of that section.

In respect to ovipositing, Davis, says, "It seems probable that the eggs may be laid in the burrows in the bud, as well as under the fibers of the leaf bases, as described by Hubbard, since in most of the fallen logs that have been seen by me, the portion near the crown was reduced to coarse powder, while the part farther down remained fairly solid." I have found no evidence to substantiate the hypothesis that the eggs are laid anywhere externally on the palms.

In observing the activities of *Dinapate* over a period of ten years during their hatching season, both at night and during the day, my observations have been as follows. Emergence of the adults always occurred nocturnally, although a very small opening may have been made during daylight hours. When final emergence took place, the beetles were fully hardened and darkened in color. Immediately they were free of the exit holes, they crawled aimlessly over the palm log, then took wing and alighted on the heavy netting spread over the logs around one end of the forty-foot insectary. The netting also covered two living young palms, *W. filifera*, about six to eight feet in height, with the leaf fans intact.

Over a period of time some 150 beetles were captured and marked with phosphorescent paint so that their activities could be observed in the dark. Large numbers painted on the elytra (odd numbers for females, even for males) were easily visible at close quarters. Although many of them congregated in the southeast corner, no mating activity was observed, but much fighting went on. Males and females, when confined together in a jar, soon lost a leg or two in combat. Twenty-seven beetles emerged from the first group of palm trunk sections. Eleven soon moved to the palm trees and began crawling over the trunks. There were seven females and four males. The females began burrowing at the bases of the leaf stems and during the night all disappeared into the tree, leaving small piles of frass at the openings of the burrows. Males then came to these burrows and tried to enter.

While the burrow was still shallow, the females would work for a time, then back out. Several times I observed them evacuating a drop of heavy liquid from the anus. As the burrow deepened, they deposited these drops here and

Fig. 1. Exit holes made by adult beetles.

there along the sides of the tunnel. Upon investigation under the microscope, the drops I examined proved to be a heavy glue-like liquid, which adhered strongly to the walls of the burrow. No ova were found in them.

The behavior of *Dinapate* is similar to that of the Shot-hole Borer, *Scolytus rugulosus* Ratz. According to Smith (1932) females of the latter cut circular holes in bark and construct tunnels into the beginning of the wood, then work up and down the limb through the inner bark and cambium. They lay their eggs along the sides of the tunnel, then embed them in shredded bark and wood. While boring the tunnel, each female is usually accompanied by a male. The males of *D. wrighti* also attend females who have begun tunneling into the palms. Sometimes several males collected about the tunnel entrance of a female, and as the tunnel deepened, they became very active and followed the female into the tunnel. There were audible sounds of fighting within, and some males would back out missing a leg or two, or with chunks bitten out of their elytra. The only time I have seen the males interested in the females was when the latter began making their tunnels. This leads me to believe that mating takes place within the tree.

The eggs probably hatch within a few days to a week after having been deposited in the soft material at the bottom of the chamber made by the females at the base of the crown. It is an ideal incubation chamber in which the young grubs can develop.

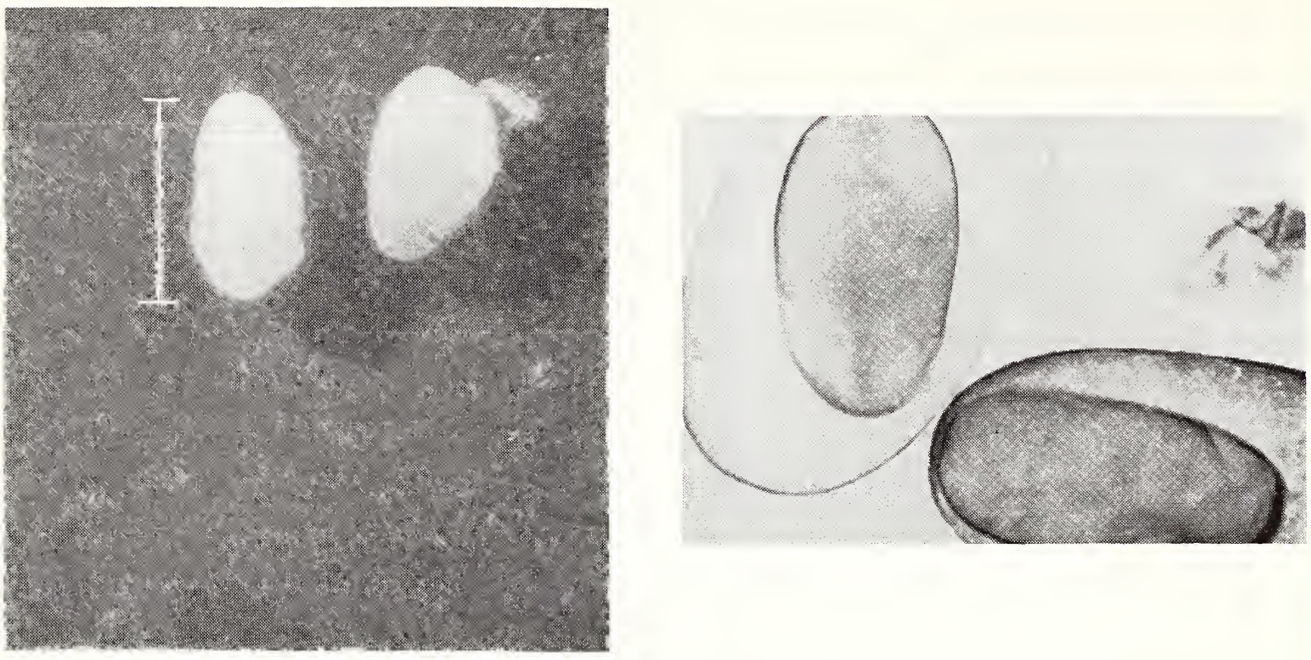

FIG. 2. Obovate eggs (left) which when cleared (right) in clove oil become transparent and show the embryo.

Davis (1940) states that the egg of *D. wrighti* has never been described and that in females cut when opening palm logs, no eggs were found in the ovaries. Two females that I kept separately in jars oviposited, and I was able to examine the eggs. The egg of *Dinapate* is obovate, averaging 1.75 mm. in length and .90 mm. in width. The outer surface is a moist, soft, yellowish-white capsule, fairly smooth and opaque. When cleared in clove oil it becomes transparent and the embryo can be seen (Fig. 2). Only two of the dead females dissected were found to contain ova.

A total of 557 beetles were reared in the insectary from palm sections taken at three oases in Thousand Palms Canyon, California. There were 381 females and 176 males. Males varied in size between 48 mm. to 52 mm. and females from 38 mm. to 43 mm. (Fig. 3). These variations probably result from climatic

FIG. 3. Left: ♂ of normal size: center: ♀ of normal size and right: ♀ of small size.

Fig. 4. Dissection showing mass of eggs in abdominal cavity.

conditions and the amount of food consumed by the grub. I found 29 females which were much smaller than normal—from 28 mm. to 35 mm. They were duller and a few had a definite reddish-brown color. The "norms" were dark polished brown. Only two of the dead females dissected contained ova. Four hundred forty-five eggs were counted in the smaller one (Fig. 4) and the one of "normal" size contained only 154 eggs. In the latter, much of the abdominal cavity was taken up by a large, obovate proventriculus. Dissection revealed two sclerotized structures, almost filling the proventriculus, in a position indicating that they moved one upon the other to grind the palm fibers. The inner wall of the proventriculus was heavily denticled by small blunt, slightly curved "teeth."

The proventriculus of the smaller female was narrower and elongate. The inner wall was denticled, and attached to one side was an elongate dark section, shaped somewhat like a radula which was hard and packed with rows of tooth-like structures which were an integral part of the wall. Morphologically the females appear identical; but the great difference in the proventriculi leads me to think that there may be two forms. Unfortunately I have not yet had time to carry this work farther or to examine the proventriculi of the males, and I must await the emergence of more adults.

The mass of eggs in each female was completely enveloped in a stringy, web-like net, which apparently holds them together. Examination under the microscope showed this stringy material to be similar to spider webbing. The

abdominal cavity contained a large amount of whitish fatty substance. A single gland, lying ventrally below the egg mass in the abdomen, was discovered. Tubules of varying sizes extended from it, apparently open and not attached to any other organs. Since no other similar gland was found, it could be the source of the web-like material binding the eggs together. This is hypothetical, and additional work needs to be done to determine the function of this gland.

Since *D. wrighti* cannot be studied under its natural conditions without considerable expense and time-consuming effort, it may be some time before its biology and life history are completely known. Under artificial conditions, the adults after emergence live only a week or two. I have had eggs from two living females; but all efforts to culture them failed. They may not have been fertile.

The exact period of development from egg to adult is unknown. Campbell (1923), from his observations of beetles reared in his laboratory, suggests that this period may be from three to five years. At the moment, I concur. However, I have a young *W. filifera* in the insectary covered by a wire screen cage in which twelve females made their tunnels in 1966. To date (November, 1970), no beetles have emerged. This would indicate that the life history may be more than three years. It would be unwise to do more than hypothesize here, since the beetles were reared under artificial conditions in an area where the climate varies radically.

DISTRIBUTION

Wherever the oases of the California fan palm, *W. filifera*, were investigated, either the presence of *D. wrighti* Horn was discovered, or evidence of their presence was noted. Even in the Badlands of Borrego Desert State Park in southern California, where occasional small stands of palms—from one to several in a group—were found, there was evidence of the beetle. The palms here are widely scattered in a vast area of arid terrain consisting of many low tors and deep washes. I have yet to investigate sections in this area where oases have been seen from an airplane, but are difficult of access on foot. Michelbacher and Ross (1939) verified Hubbard's conjecture that the beetles were found as far south in Lower California as Catavina, some 300 miles south of Palm Springs, California. Nelson (1921) noted the presence of *Washingtonia* fan palms as far south as the lowlands and mountains of Sinaloa and southern Sonora on the mainland of Mexico, but made no mention of the beetles. In correspondence with Professor J. N. Mathieu, of the Instituto Technologico y de Estudios Superiores de Monterrey, Monterrey, N.L., Mexico, he explained that *Washingtonia* fan palms were not endemic to this area, but were planted as ornamentals. He found no evidence of the beetles. This is understandable, since *D. wrighti* is known to occur only in arid regions at lower altitudes.

Fig. 5. Isolated *W. filifera* palm in the Badlands of Borrego Desert, California.

Davis (1940) states that the beetles may also occur in the canyons opening into the Borrego Valley. I found evidence of their presence here, although I was unable to collect any palm logs.

E. A. Kane, survey entomologist of the Kern County Department of Agriculture, informed me that he suspected the presence of *D. wrighti* in palms at Oildale, California. He stated that beetles had been taken in the area some 30 years ago. Oildale is about 185 miles north and west of Twentynine Palms, which is the northernmost limits of so-called "natural" stands of *Washingtonia* palms and also *D. wrighti*. Since this is recent information, I have had no opportunity to verify it; these palms were undoubtedly transplanted, and the grubs or eggs of *D. wrighti* may already have been inside the trees.

In a recent communication C. E. Langston, entomologist, Kern County California Department of Agriculture, states that *D. wrighti* was taken from *Washingtonia* palms about a mile and a half from Oildale, California. He gave no date. There is a report (unverified) that the beetles may also occur in the Kofa Mountains in Yuma County, Arizona.

I have been unable to find fossil records of either *W. filifera* or *D. wrighti*. Dr. J. A. Wolfe, U.S. Department of the Interior, Geological Survey, Branch of Paleontology and Stratigraphy, informed me by correspondence that no fossil palms have been assigned to the Genus *Washingtonia*, and that fossil palm leaves are not particularly diagnostic.

FIG. 6. Collection sites of *D. wrightii*. Question marks indicate areas still to be investigated.

CONCLUSIONS

The time from egg to adult appears to be from three to five years, depending upon temperature, humidity and other ecological conditions. Several broods may occur in the same trees of the larger palms, and over the years this constant activity may kill the trees. The first sign is the drying and browning of the leaves, due to constant eating out of the crown bases. In trees that have been so killed, the crowns eventually fall off. Trees that have fallen and lain for some time may contain living grubs. Apparently even the dry fibers of dead trees afford nourishment for them. Cellulose-conversion is possibly accomplished by bacterial action since no protozoan parasites were found in the gut.

After emergence, particularly in large oases of older palms, the adults may begin re-burrowing into the same tree. They are capable of long flights, and may fly to other trees in the same oasis, or even to palms many miles distant. Such flights are made soon after emergence. If competition is great, entire broods migrate to other groves. Palms are probably located by olfactory structures in the antennae.

There appears to be no danger of the palms being wiped out through their activities, since some of the larger oases are known to have existed for perhaps a hundred years or more, and have no doubt been infested long before the discovery of the beetles in 1886. New palms are constantly springing up from the dropped seeds, especially in the larger oases. In every stand of palms investigated, some evidence of the beetles—or their presence—was noted.

The worst enemies of the beetles, at least when in flight, are large insectivorous bats. In the trees they may be killed by fungi. The only parasite known at present which attacks the grubs and adults is the dipterous parasitic fly, *Sarcophaga helicis* (Aldrich, 1915).

The *Washingtonia* fan palm and the giant palm-boring beetle seem ecologically well balanced.

Literature Cited

Aldrich, J. M. 1915. Sarcophagidae, economic relations. J. Econ. Entomol. A dipterous parasite of *D. wrightii* Horn.

Anderson, W. H. 1939. Key to Larval Bostrichidae. In U.S. Nat. Mus. J. Washington Acad. Sci., **29** (9) 382–91.

Axelrod, D. L. 1950. Studies in late tertiary paleobotany. Contributions to Paleobotany, Carnegie Inst., Washington, D.C., Pub. No. 590, 144–45.

Campbell, R. E. 1923. Notes on the life history of *Dinapate wrightii* Horn. J. Entomol. and Zool. Pomona College, **15** (4) 61–65.

Comstock, J. A. 1922. A giant palm-boring beetle, *Dinapate wrightii* Horn. Bull. Southern California Acad. Sci., **21** (1) 5–17, 2 pls.

Davis, A. C. 1940. Notes on *Dinapate wrightii* Horn (Coleoptera: Bostrichidae). Proc. Entomol. Soc. Washington, **42** (6) 129–34.

Elmer, H. S. (no date). Date palm insect and mite pests in the U.S. Reprint from date

growers' Inst. Report #43, pp. 9–14. (Elmer—U.C. Citrus Res. Center and Agr. Exp. Sta., Riverside, California.)

FISHER, W. S. 1950. A revision of the North American species of beetles belonging to the family Bostrichidae. U.S.D.A. Bull. **698**: 1–157.

GARNETT, R. T. 1918. Notes on *Dinapate wrightii* Horn. Entomol. News, **29** (2) 41–44, pl. 2.

HORN, G. H. 1886. *Dinapate wrightii* and its larva. Trans. American Entomol. Soc., **13**, pp. 1–4, pl. 1.

HUBBARD, H. G. 1899. Letters from the Southwest. The home of *Dinapate wrightii* Horn. Entomol. News, **10** (4) 83:89.

MARTIN, J. O. 1928–29. Report on the work of *D. wrightii* Horn in the fan palms, *Washingtonia filifera* by Dr. Stickney. Proc. Pacific Coast Entomol. Soc. **2** (8).

———. 1917. In quest of *Dinapate wrightii* Horn. Bull. Brooklyn Entomol. Soc. N.S., **xii** (1) 107–10.

MICHELBACHER, A. E., and ROSS, E. (U.C., Berkeley). 1939. The giant palm borer (Col. Bostrichidae), an economic pest in Lower California. Bull. California State Dept. Agric., **xxviii** (2) 166–69.

NELSON, E. W. 1921. Lower California and its natural resources. Memoirs of the Nat. Acad. Sci., **16** (1) 1–194.

SMITH, L. M. 1932. The Shot-Hole Borer. California Agric. Ext. Serv. Circular 64, College of Ag., U. of Calif., Berkeley, Calif.

STICKNEY, F. S., BARNES, D. F., and SIMMONS, P. 1950. Date Palm insects of U.S. 1950. U.S.D.A. Circ. No. 846.

WYMORE, F. H. 1928. On *Dinapate wrightii* Horn. The Pan-Pacific Entomol. **4** (3) 143.